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Extraperiosteal Plating of Pronation-Abduction Ankle Fractures

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Background: Pronation-abduction ankle fractures frequently are associated with substantial lateral comminution and have been reported to be associated with the highest rates of nonunion among indirect ankle fractures. The purpose of the present study was to report the technique for and outcomes of extraperiosteal plating in a series of patients with pronation-abduction ankle fractures.

Methods: Thirty-one consecutive patients with an unstable comminuted pronation-abduction ankle fracture were managed with extraperiosteal plating of the fibular fracture. The average age of the patients was forty-four years. There were nineteen bimalleolar and twelve lateral malleolar fractures with an associated deltoid ligament injury. No attempt to reduce the comminuted fragments was made as this area was spanned by the plate. The patients were evaluated functionally (with use of the American Orthopaedic Foot and Ankle Society score), radiographically, and clinically (with range-of-motion testing).

Results: Immediate postoperative and final follow-up radiographs showed that all patients had a well-aligned ankle mortise on the fractured side as compared with the normal side on the basis of standardized measurements. All fractures healed without displacement. At a minimum of two years after the injury, the average American Orthopaedic Foot and Ankle Society score (available for twenty-one patients) was 82. The range of motion averaged 13° of dorsiflexion and 31° of plantar flexion, with one patient not achieving dorsiflexion to neutral. There were no deep infections, and one patient had an area of superficial skin breakdown that healed without operative intervention.

Conclusions: Extraperiosteal plating of pronation-abduction ankle fractures is an effective method of stabilization that leads to predictable union of the fibular fracture. The results of this procedure are at least as good as those of other techniques of open reduction and internal fixation of the ankle, although specific results for pronation-abduction injuries have not been previously reported, to our knowledge.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.
causing either a disruption of the deltoid ligament or an avulsion-type fracture of the medial malleolus. A stage-2 pronation-abduction injury will proceed to either an impact injury of the lateral tibial plafond or a disruption of the syndesmosis. The translational force exits at the fibula in the third stage, resulting in a transverse fracture that is often comminuted laterally, consistent with a bending failure (Fig. 1). The displacement of the talus is lateral, rather than more posterolateral, as is the case with other Weber type-C injuries that occur in rotation. The reduction and fixation of this particular injury should be distinguished from those of other suprasyndesmotic fractures on the basis of the direction of instability. At our institution, stage-3 pronation-abduction ankle fractures account for <9% of all ankle fractures. Substantial lateral comminution of the fibula makes the operative treatment of this type of ankle fracture challenging. Traditional subperiosteal plating techniques strip the remaining soft tissue from the fracture, making the fragments extremely difficult to align and stabilize with a lateral plate, which has led some authors to recommend bone-grafting for comminuted fractures. Extraperiosteal fixation techniques, which preserve the periosteum and indirectly reduce comminution, have been used for the treatment of other long bones. The purpose of the present study was to report the technique for and outcomes of extraperiosteal plating of the fibula for the treatment of unstable pronation-abduction ankle fractures.

**Materials and Methods**

Over a seventy-two-month period, thirty-one skeletally mature patients with a closed, unstable pronation-abduction ankle fracture were managed at a level-I trauma center by a single surgeon (P.T. III). Routine ankle radiographs, including anteroposterior, lateral, and mortise views, were made. In all cases, the fibular fracture extended to within 2 cm of the tibiotalar joint, precluding the use of syndesmotic fixation only.

**Surgical Procedure**

Once the soft tissues were amenable to surgical intervention, the planned procedure was undertaken. If a medial malleolar fracture was present, the first step was to open the medial fracture site, to reduce the fragment or fragments, and then to stabilize the fracture with lag screws. If the medial injury was a deltoid rupture, it was not addressed surgically. Subsequently, a direct lateral incision was utilized to access the fibular fracture. A careful extraperiosteal dissection was performed, with the soft-tissue sleeve surrounding the comminuted fracture fragments being left as intact as possible. A nonlocking, one-third tubular plate was precontoured to fit the anatomy of the lateral aspect of the distal part of the fibula. Through fixation of the medial malleolar fracture (when present) and manipulation of the foot, a tentative indirect reduction of the fibula was obtained. As the lateral ankle ligaments, particularly the calcaneofibular ligament, are intact in this injury pattern, reduction of the talus under the plafond pulled the distal part of the fibula out to length in most cases. Length was confirmed by means of radiographic comparison with the normal side with use of standard radiographic landmarks such as the fibular notch and the talocrural angle. If length was not restored, then a bone tenaculum was used to directly pull the distal part of the fibula distally, restoring length. In these cases, a Kirschner wire was used to hold the fibula in position until fixation in the fragment was placed through the plate. The plate was then placed against the fibula, superficial to the periosteum. Radiographs that were made at this time often revealed mild residual lateral fracture displacement (Fig. 2-A). In all cases, fibular length was reestablished prior to proximal fixation. Screws typically were placed sequentially through the plate from proximal to distal in the proximal fragment, which allowed the plate to be utilized as a reduction tool, with the distal part of the fibula being pushed medially as the screws were placed (Fig. 2-B).

In five ankles, screws were placed in the distal fragment to help to maintain length. After fixation was achieved, fibular length was again confirmed radiographically by visualization of the fibular fracture fragments and by comparison with the
other ankle. In particular, the talocrural angle was used to confirm the accurate restoration of fibular length and the congruence of the ankle mortise (Fig. 3). Additionally, the medial clear space and the tilt of the talus in the mortise were compared between sides. If intraoperative evaluation following lateral fixation demonstrated that the syndesmosis was unstable, syndesmotic screws were placed through the plate, which acts as a substitute lateral cortex in order to stabilize the syndesmosis (Figs. 4-A and 4-B). If the medial injury was ligamentous, instability was identified by measuring the medial clear space and the syndesmotic space or by identifying any lateral subluxation of the talus radiographically with the application of an abduction stress on the ankle. If medial fixation had been performed, then a laterally directed force was applied with use of a clamp placed on the fibula to test for syndesmotic instability, which was defined as the occurrence of >2 mm of lateral translation of the fibula with respect to the tibia at the syndesmotic notch with the foot held in a neutral position. If syndesmotic fixation was placed, the patient was given the option of removal at a minimum of three months. There was no attempt to reduce the comminuted fibular fracture fragments. The plate simply spanned the comminution of the fibula, analogous to “bridge plating” in other long bones. No bone-grafting was performed. All patients were managed with a cast postoperatively and were kept non-weight-bearing.

Results

The study group included sixteen men and fifteen women with an average age of forty-four years (range, nineteen to seventy-six years). The average time for fibular fixation was sixteen minutes (range, ten to thirty-two minutes) from incision to fixation. There were nineteen bimalleolar fractures (OTA type 44C2.2) and twelve lateral malleolar fractures with an associated deltoid ligament injury (OTA type 44C2.1). Eighteen patients had medial-sided fixation, and twenty-three (including fourteen of the nineteen with a bimalleolar fracture and nine of the twelve with a lateral malleolar fracture) had placement of syndesmotic screws. One patient with an anterior collicular fracture and poor medial skin had nonoperative treatment of a medial malleolar fracture, which went on to a painless, fibrous union.

Immediately postoperatively, all patients had a well-aligned mortise on the fractured side as compared with the normal side on the basis of measurements of the medial, superior, lateral, and syndesmotic spaces, the position of the fibula on the lateral view, and the talocrural angle (which measured within 2° of that on the normal side). All fibular fractures healed without displacement within ten weeks. One patient was lost to follow-up after fracture union had occurred. Of the remaining thirty patients, twenty-one were followed for a minimum of two years (average, 2.3 years; range, two to four years). The average American Orthopaedic Foot and Ankle
Fig. 3
After indirect reduction, the talocrural angle on the affected side (left) is within 1° of that on the normal side (right), providing an objective measure of fibular length and congruence of the mortise.

Figs. 4-A and 4-B Postoperative anteroposterior and lateral radiographs. Intraoperative evaluation revealed an unstable syndesmosis. Therefore, a syndesmotic screw was placed through the plate, which acts as a substitute lateral cortex.
femora, Farouk et al.16,17 showed that minimally invasive plate
ation with femoral fractures. In studies involving cadaveric
concept has been applied to long-bone fractures of the femo-
vasive reduction in order to obtain stable fixation6.

Discussion

U
stable stage-3 pronation-abduction ankle fractures result
in laterally comminuted fibular shaft fractures because of
the bending moment at the time of fracture. The resultant frag-
mented bone is challenging to adequately align while maintain-
ing satisfactory vascularity for fracture-healing. A classic direct
open fracture reduction and rigid plate fixation will violate the
soft-tissue attachments of the fragments and jeopardize the vi-
ability of the injured bone21,22. The surgical site is therefore placed
at risk for nonunion and infection.

Because the endosteal blood supply is interrupted in asso-
iation with a comminuted shaft fracture, the vitality of the bone
depends on the periosteal vasculature and adjacent mus-
culature, as does fracture-healing. One way to obtain stability
while protecting the soft tissue is to apply a plate outside of
the periosteum, bridges the comminuted fragments. The concept of in-
tramedullary nail or a cast. It allows micromotion at the
fracture site similar to the level of fixation provided by an
intramedullary nail or a cast. It allows micromotion at the
fracture site but does not violate the delicate biology necessary
for bone-healing; therefore, interfragmentary callus forms and
the fracture proceeds to union4,15.

Indirect reduction techniques imply that the fracture
site is not directly violated and therefore its soft-tissue enve-
lopes remains mostly intact. Ligamentotaxis and utilization of
a plate as a reduction tool can be used to assist with the less in-
vasive reduction in order to obtain stable fixation4.

These concepts have been explored extensively in associ-
ation with femoral fractures. In studies involving cadaveric
femora, Farouk et al.4,17 showed that minimally invasive plate
osteosynthesis was superior to conventional plate osteo-
synthesis for preserving arterial femoral vascularity and perfu-
sion. Other investigators have shown that union through
callus formation, similar to that achieved with intramedullary
fixation, can be obtained safely with a decreased need for
bone-grafting and a decreased risk of infection through this
minimally invasive, submuscular plating technique4,15. This
concept has been applied to long-bone fractures of the femo-
ral shaft as well as to periarticular and intra-articular fractures of both the femur4 and the tibia4.

In 1987, Limbird and Aaron4 reported on a series of eight laterally comminuted ankle fracture-dislocations in
which anatomic reduction of the mortise and restoration of fibril length had been difficult to achieve secondary to dis-
continuity of the fibula. All of the patients underwent trad-
tional open reduction and internal fixation, which included
stripping the periosteum and opening the fracture site. The
authors identified comminution of the distal part of the
fibula as the cardinal feature of the injury but also reported
that the anterior tibiofibular ligament was torn in all cases.
Bone-grafting of the fibular defects was performed in six of
the eight patients. The two fractures that did not receive bone
graft went on to nonunion and required further revision sur-
gery with secondary bone-grafting. These injuries were con-
sistent with a pronation-abduction pattern ankle fracture.
Similarly, Ebraheim et al.4 reported on nine Weber type-C,
stage-3 pronation-abduction ankle fractures that were treated
with traditional open reduction and internal fixation. Five re-
quired syndesmotic fixation. There was one delayed union
and one nonunion. Those authors also recommend bone-
grafting for high-energy fractures with comminution.

In the current series, after stabilization of the medial os-
seous injury (when present), a precontoured plate was placed
directly laterally outside of the periosteum, spanning the area
of fracture comminution, similar to a bridge plate. The direct
lateral location opposes the abduction moment that caused
the original injury. The extraperiosteal position precludes
the need for bone graft, decreases the risk of infection, and pro-
vides the most biologically friendly environment for union.
Also, using the plate as the reduction tool allows the soft-
tissue envelope to be preserved while still allowing appropriate
length and alignment to be obtained. All fractures in the
present series exhibited a well-aligned mortise and went on to
union without bone-grafting.

In 1978, Pankovich36 described a series of ankle fractures
that included fourteen pronation-abduction injuries (five of
which were stage 2 and nine of which were stage 3). Fixation
of the medial side only did not restore stability in the patients
with stage-2 injuries, and all required syndesmotic fixation.
Six of the nine patients with a stage-3 fracture had persistent
instability of the ankle after plating of the fibula and required
syndesmotic fixation. Eleven of these fourteen patients
achieved a painless ankle with a normal or nearly normal
range of motion. In the current series, the syndesmosis was
stressed after lateral fixation was completed15. When necessary,
syndesmotic screws were placed directly through the plate. In
such cases, the lateral plate serves as a substitute lateral cortex,
which adds greater strength to the syndesmotic fixation as
these screws often traverse the comminuted area of the fibula.

The technique of extraperiosteal plating of pronation-
abduction fibular fractures has been described previously36. A
lateral buttress plate, usually applied outside of the perios-
team, bridges the comminuted fragments. The concept of in-
direct reduction with use of a plate also has been described for
the treatment of high fibular fractures associated with a syn-
desmotic injury21. With this technique, distal fixation is per-
formed first and then the fibula is subsequently pushed out to
length before the proximal screws are placed. We prefer to per-
form proximal fixation first because manipulation of the foot
combined with medial fixation, when necessary, generally re-
stores fibular length, obviating the need for distal fibular fixa-
tion in most cases. The plate acts as a push plate, reducing the
fibula and centering the talus within the mortise. In our series, only five of the thirty-one fractures required distal fibular fixation to maintain length.

There is only limited information regarding the outcomes of unstable ankle fractures. Lindsjö reported limited functional ability to work in 90%, to do physical activity and play sports in 82%, and to walk in 89% of patients in that series, as well as good range of motion, after surgical treatment of ankle fractures. In a retrospective review in which patients with operatively treated ankle fractures were compared with a group of control subjects, Belcher et al. reported functional impairment at eight to twenty-four months postoperatively despite adequate reduction and no radiographic evidence of degenerative changes; however, the study did not address whether these differences significantly impacted the patients’ quality of life. Obremskey et al. observed that although patients continue to show improvement in function for as long as twenty-four months after surgical fixation, residual physical and functional effects can be expected. The degree to which these residual effects impact the quality of life is low. These reports are consistent with our findings, as all of our radiographs revealed osseous union with a well-aligned mortise and a stable joint and all patients but one had good range of motion.

In the present series, we found extraperiosteal plating to be an effective method for the stabilization of pronation-abduction ankle fractures. The technique allows for accurate reduction of the mortise without stripping the periosteum of the comminuted region of the fracture. In contrast with previous work, bone-grafting was not used and yet all fractures healed. The outcomes were similar to those in other series of ankle fractures after open reduction and internal fixation, although we believe that the present study represents the first series that has been limited to only pronation-abduction injuries. The technique is easier and faster than standard techniques in which the lateral periosteum is split to facilitate placement of the plate. We recommend this technique for the treatment of comminuted pronation-abduction ankle fractures. Medial fixation, specific attention to restoring the length of the fibula and the fibular position as seen on the lateral radiograph, and evaluation of the syndesmosis after fibular fixation are essential elements of the technique.

References

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